

# IT'S HERE ...GET PREPARED FOR HURRICANE SEASON!

By Anne Donovan, CZM

June 1 marks the beginning of the 2002 hurricane season—and all signs point to an active 6 months of storms. Generally peaking in August and September, the hurricane season officially extends all the way through November. Although Massachusetts has been spared from a truly major hurricane for more than a decade, now is the time to get prepared for the inevitable return of a severe storm.

## ANATOMY OF A HURRICANE

The hurricanes that make their way to the Bay State are born in the tropical waters off the coast of Africa, in the Caribbean, or in the Gulf of Mexico. These cyclones are giant heat engines that thrive on the warmth and moisture of these tropical seas, where storms typically flourish. If a developing storm encounters a wind pattern that sets off the characteristic counter-clockwise rotation of a Northern Hemisphere cyclone (in the Southern Hemisphere, the rotation of the earth creates a clockwise motion), a tropical storm may be born, and once born, given a name and an identity (see *It's All in a Name* on page 10). Spiraling around its extreme low-pressure center, which will ultimately become the “eye,” the storm siphons heat and moisture from the sea. Sucked through the eye and above the storm, the air cools and condenses, expanding and falling as rain. As long as the heat and the moisture source continues, the storm can grow in intensity, spiraling wildly around the eye and growing up to 500-miles wide.

The energy created through a hurricane is tremendous; if it could possibly be harnessed, one hour of hurricane energy would supply the electrical needs of the entire United States for a year. The quantity of water involved is also staggering. A typical hurricane drops 2 billion tons of water a day.

Northeasters—named for the direction their winds come from—are also cyclones, but start in the north Atlantic when cold air from the land clashes with warm ocean temperatures from the Gulf Stream. Unlike hurricanes, whose season runs from late spring through fall, Northeasters are typically seen in Massachusetts from October to April. But, these major weather events can look very much alike, despite the differences in their origins.

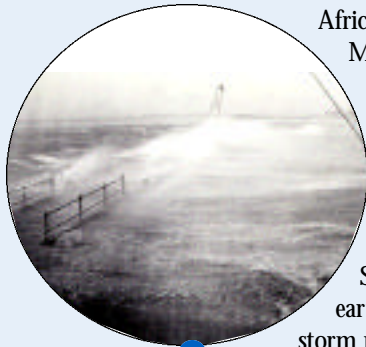
## THE TRIPLE THREAT: SURGE, WINDS, AND FLOODS

In Massachusetts, we are in the unenviable position of being vulnerable to all the possible threats from a hurricane: relentless storm surge at the coast, high winds battering coastal and inland areas, and torrential floods in streams and rivers from the tip of Cape Cod to the Berkshires. While recent tropical storms have caused all three of these conditions in the Bay State, it has been almost 50 years since a Category 3 hurricane has hit here, and more than 10 years since we've seen a Category 2. (See *1 through 5: The Hurricane Categories* on page 11.)

**STORM SURGE** - Pushed toward the shore by powerful winds, storm surge is a dome of water, often up

to 50 miles wide. Topped with violent storm waves, this pile of water climbs over the normal tide. With luck, the surge will hit at low tide, consequently muting its impact. But, on top of a high tide, storm surge can be devastating, raising water levels by more than 25 feet at its worst and essentially bulldozing everything in its path. Luckily, hurricanes are generally fast-moving storms in New England, with the worst of the winds passing in a manner of hours. Unlike Northeasters that can linger over several tidal cycles, the narrow window for hurricane storm surges often misses high tide altogether. This numbers game doesn't change the fact that if storm surge and high tide coincide, the outcome can be disastrous. For coastal areas, this wall of water holds the most potential danger. With the most severe impacts felt near where the eye of the storm hits land, storm surge can crush vessels and structures, erode miles of beach, and undermine inappropriately designed or low-lying buildings.

**WINDS** - Gusting at least 74 miles per hour (mph), hurricane winds can be devastating. These winds pick up debris of all kinds, transforming it into missiles hurtling through the air. Winds also tear at rooftops and shingles, blow in windows, and when strong enough, can even topple over mobile homes and other small structures, as well as larger buildings in the wrong place at the wrong time. Hurricanes can also spawn tornadoes, with their extreme but targeted wind damage.



HURRICANE  
OF 1938:  
HEAVY SURF IN  
WOODS HOLE.

All hurricane photos, unless otherwise noted, courtesy of NOAA



**FLOODS** - The rains from hurricanes can continue well after the wind and storm surge have passed. In New England, these storms can dump up to 6 to 12 inches of rain, flooding streams and rivers throughout the state. These rising flood waters damage roads, homes, and buildings of all kinds, disrupting transportation, contaminating water supplies, and creating a waterlogged mess requiring months to years of cleanup. It is this lingering threat that proves most deadly, with more people losing their life from hurricane floods in the last 30 years than from storm surge and wind combined.

#### THE COMMONWEALTH COASTLINE AT RISK

Mid-Atlantic, southeastern, and Gulf States usually bear the brunt of hurricane forces, but by virtue of our geography, Massachusetts is also vulnerable. Jutting eastward into the Atlantic, Cape Cod, the Islands, and everything to their west lie exposed to storms tracking up the east coast. The cooler waters off our shores do offer some protection, sapping the energy from the storm as it approaches. Although this hurricane-muffling system keeps us relatively sheltered from a Category 4 or 5 hurricane, it is no guarantee. In fact, four major hurricanes (Category 3) hit Massachusetts in the last century alone.

The counter-clockwise motion of the hurricane means that the winds are worst to the right of the storm path, while the rains are worst to the left. Storm surge is greatest right around the eye. For storms with eyes that make landfall along the South Coast, therefore, Buzzards Bay gets the worst

of the storm surge, acting like a giant funnel, channeling this dome of water toward these susceptible coastal communities. Cape Cod, along with the storm surge, gets battered with southwesterly winds and waves. When the eye hits east of the Cape, however, the predominant winds are from the northeast, causing the storm to act more like a Northeaster, packing its biggest punch from Cape Cod Bay northward.

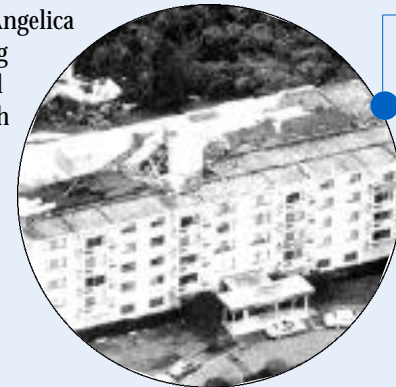
These natural risks from hurricanes have existed for centuries, significantly altering the Commonwealth's landscape by periodically sculpting the shoreline, leveling inland forests, and flooding rivers, streams, and surrounding lowlands. The unprecedented development in Massachusetts over the last 50 years, especially along the coast, means that the periodic and natural effects of hurricanes can mean tremendous losses.

#### THE WORST MASSACHUSETTS HURRICANES OF THE 20<sup>TH</sup> CENTURY

The worst hurricanes to hit Massachusetts in the last 100 years, in reverse order, are: Hurricane Bob in 1991; "the twins" from 1954, Hurricanes Carol and Edna; and last but not least, the Great New England Hurricane of 1938.

**HURRICANE BOB** - Developing in the central Bahamas on August 16, 1991, Hurricane Bob intensified and accelerated north-northeastward, paralleling the East Coast, and barreling into Block Island, Rhode Island, and later Massachusetts on August 19. Although this Category 2 hurricane was

not among the worst in terms of wind speed or storm surge, the property damage totals alone secured a top-three spot for Hurricane Bob. The Category 3 storms from earlier in the century packed more of a punch, but the extensive coastal development in the second half of the 20<sup>th</sup> Century left many more homes and other structures in the path of Bob's fury. Overall, New England experienced \$680 million in damage, \$39 million in Massachusetts alone. Most of southeast Massachusetts faced hurricane-force winds, with coastal communities in these areas seeing sustained winds of 75 to 100 mph. Brewster and North Truro experienced gusts of 125 mph, with North Truro enduring sustained winds of 100 mph. Trees and utility polls were routinely damaged, and 60 percent of the residents of southeastern Massachusetts lost power. The storm surge in Buzzards Bay was 10 to 15 feet, ripping boats from their moorings, destroying homes, and eroding large sections of coastline. Onset, Bourne, Mashpee, and Wareham saw the worst surge, 12 to 15 feet. Mattapoisett was also hit hard, with 29 of 37 homes destroyed on Cove Street and 32 of 35 homes destroyed on Angelica Point. Southern-facing shorelines experienced significant erosion, with some spots along Martha's Vineyard and Nantucket losing up to 50 feet of shoreline.



HURRICANE BOB: THE ADMIRALTY APARTMENTS IN FALMOUTH, AFTER BOB BLEW OFF A SECTION OF THE ROOF.

## HURRICANE PREPAREDNESS KIT

We've all seen it on the news. Some of us may even have experienced it first hand. Long lines at grocery stores and empty shelves at home supply warehouses as the hurricane bears down on some unfortunate coastal community. Like most things in life, the time to prepare for a hurricane is well before you hear warnings on your local radio station. In fact, the time to prepare for the 2002 hurricane season is now.

To help, the Massachusetts Office of Coastal Zone Management (CZM) has compiled a detailed Web page, listing links to all the best sources of information on hurricane preparedness. The site provides information on:

- Building and rebuilding to withstand the storm.
- Supplies to assemble at the beginning of hurricane season.
- How to develop an emergency plan for your family.
- Tips for what to bring to a storm shelter.
- Information on what to do with your pets in a weather emergency.
- Boat protection strategies.
- How to best protect yourself and your family before, during, and after the storm.
- Hurricane tracking.
- Storm prediction and hurricane warnings.
- Flood insurance.

To access the CZM Hurricane Preparedness Kit, check out our Web site at: [www.mass.gov/czm/hurricanes.htm](http://www.mass.gov/czm/hurricanes.htm). If you don't have Web access, call the CZM Information Line at (617) 626-1212 and we'll send you a printed copy. ACT NOW AND DON'T GET CAUGHT OUT IN THE RAIN AND HURRICANE-FORCE WINDS!



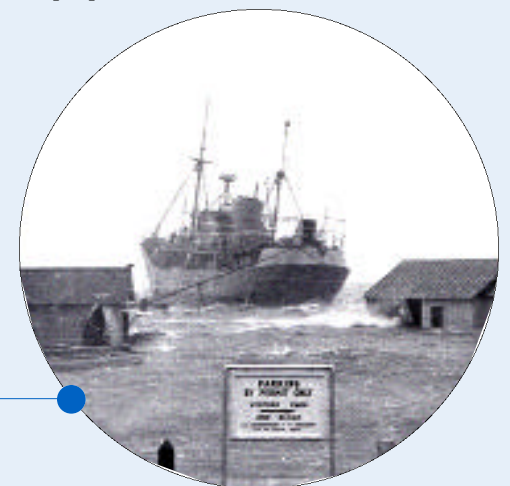
HURRICANE  
FRAN DOES  
SOME SERIOUS  
DAMAGE  
IN NORTH  
CAROLINA.

**1954** - In this year, not one but two Category 3 hurricanes hit New England, Carol and Edna. This double-whammy began at the end of August when Carol formed in the Bahamas. After several days of slow northward progress, Carol accelerated rapidly the evening of August 30, passing just to the east of Cape Hatteras, North Carolina, and continuing toward eastern Long Island and southeastern Connecticut for an August 31 landfall. Most of eastern Massachusetts saw sustained winds of 80 to 100 mph, toppling trees and miles of power lines. Strong winds caused devastation from eastern Connecticut to Cape Cod, ruining 40 percent of apple, corn, peach, and tomato crops. Making landfall just after high tide, Carol's storm surge caused massive flooding, with the Somerset and New Bedford areas receiving the worst of it in Massachusetts. New Bedford's storm surge was over 14 feet. Rainfall of 2 to 5 inches spread across the region, and peaked in north central Massachusetts at 6 inches. Throughout New England, 4,000 homes, 3,500 cars, and 3,000 boats succumbed to Carol, and most of eastern Massachusetts lost phone service and power. And if that wasn't enough . . .

Following a track slightly to the east of Carol, Hurricane Edna barreled up the East Coast, passing over Martha's Vineyard and Nantucket on September 11. All of eastern Massachusetts faced winds of 75-95 mph, with peak gusts on Martha's Vineyard of 120 mph. Portions of eastern Massachusetts and nearly all of Cape Cod and the Islands lost power. The 6-foot storm surge coupled with a rising tide caused severe flooding on Martha's Vineyard, Nantucket, and Cape Cod, and many boats were lost in this region as well. Because Carol had so heavily eroded beaches just days before, these areas were more vulnerable to this second storm. (See *The Art and Science of*

*Identifying Flood Zones* on page 26 for more on how cumulative impacts and a lack of recovery time can compound the destructiveness of a storm.) Also, with the storm passing to the east, a heavy rainfall of 3 to 6 inches covered most of Massachusetts, with northeastern parts of the state receiving 7 inches. Still saturated from the rains of Carol, the area experienced extensive urban and stream flooding, with street washouts common, especially in northeast Massachusetts where rivers rose several feet above flood stage. Overall, 21 people died throughout New England as a result of this storm.

Storms are unpredictable, and "100-year" events can happen in rapid succession. (See *100 Year Floods Don't Come on Schedule* on page 15.) Less than a year after Carol and Edna, Connie and Diane brought more destruction to the region. Both storms started as hurricanes, but came ashore in North Carolina, weakened, and moved northward bringing colossal amounts of rain. Together, they dumped almost 25 inches of rain in parts of Massachusetts, causing unprecedented flooding, with 40 percent of downtown Worcester submerged. More than 100 homes were lost in New England, another 1,500 damaged, and 90 people were killed.



HURRICANE OF 1954:  
ALBATROSS III BREAKING LOOSE  
FROM A PIER IN WOODS HOLE.

1938 - Undoubtedly, the Massachusetts hurricane of the century was the Great New England Hurricane of 1938. Developing off the Cape Verde Islands on September 4, this storm took an unusual track over the Gulf Stream, maintaining its strength over these warm waters until it crashed into Long Island on September 21. The winds were devastating, with the Blue Hill Observatory recording the strongest winds ever for the region, 121 mph sustained winds and gusts of 186 mph. Roofs, trees, and crops were extensively damaged and power outages were widespread, lasting for weeks in some areas. The storm surge was substantial, causing 18 to 25 foot tides from New London east to Cape Cod. Downtown Providence was covered with 20 feet of storm tide and sections of Falmouth and New Bedford were buried under 8 feet of water. Western Massachusetts saw 3 to 6 inches of rain. In Springfield, the Connecticut River rose 6 to 10 feet above flood stage. Overall, 8,900 buildings were destroyed in New England, and another 15,000 were damaged. Coastal communities were decimated; 2,600 boats were destroyed and another 3,300 damaged, and fishing fleets suffered terribly, with 2,605 vessels destroyed and 3,369 damaged. A total of 564 people were killed and another 1,700 injured in southern New England.

#### WHAT'S IN THE BAY STATE'S FUTURE?

When a storm the size of the '38 Hurricane hits again, emergency management professionals expect considerable flooding, erosion, and property loss. Sixty-four years ago, Massachusetts was predominantly farmland, and what development existed along the coast was mostly small, summer cottages. Now, sprawling cities and suburbs have replaced open farmland; coastal communities face continual construction along the shore with year-round

residences, many of substantial value; and what isn't developed has largely been transformed from farm to forest. Storm surge in developed areas will swallow houses, businesses, and roads along with beaches and dunes. Torrential rains will find more impervious surfaces, increasing runoff and exacerbating flooding impacts. Wind will topple trees, small structures, and much that is not adequately anchored. The storm surge and floods will wreak havoc on septic systems, oil tanks, and the many other low-lying products of development vulnerable to the onslaught of water.

Hurricane Bob clearly demonstrates our increased vulnerability to coastal storms. At only a Category 2 hurricane, Bob caused millions of dollars of damage. Even the Blizzard of '01, a Northeaster with 45 mph sustained winds and a storm surge of only 2.5 feet (which would be equivalent to a relatively lackluster tropical storm), caused significant damage along our developed coastlines, crumbling seawalls and flooding low-lying roads. Stronger winds and a higher storm surge would pose a far more significant threat to coastal communities.

#### 2002 HURRICANE FORECAST

Dr. William Gray of Colorado State University, world-renowned hurricane forecaster, indicates that 2002 is shaping up as an active year. On average, we see almost 10 tropical storms each year in the Atlantic. This year, Gray's April predictions call for 12 named tropical storms, 7 of these hurricanes, and 3 of these major hurricanes (at least a Category 3). This forecast says there's a 75 percent probability of one of these major hurricanes hitting somewhere along the U.S. coast. (Gray's forecast will be updated May 31. See the Colorado State University Web site at <http://tropical.atmos.colostate.edu/forecasts/> for details.)

## 6 STEPS TO PREPARE FOR HURRICANE SEASON

Before the storm, the Massachusetts Emergency Management Web site (<http://www.state.ma.us/mema/prepare/hurricane.htm>) suggests you take the following actions to get prepared:

- Plan and practice evacuation routes. Your community may have a designated route; contact the local emergency management agency for details.
- Assemble a disaster supply kit in a waterproof container that includes nonperishable foods, drinking water in non-breakable containers, cooking utensils (including a can opener), identification and valuable papers in a water-proof container, personal hygiene items, first aid kit, medications, battery-operated radio, flashlight, extra batteries, sleeping bag, pillow, sheets, change of clothing, rainwear, and toolkit.
- Make arrangements for pets. It is the policy of shelters not to allow pets. You may want to contact animal boarding facilities or hotels for emergency information.
- Protect your windows. Permanent shelters are the best protection, but plywood panels will also work.
- Purchase flood insurance. (See Flood Insurance ... Are You Covered? on page 15.)
- Develop an emergency communication plan. If family members get separated during a disaster it is helpful to have a friend or relative, outside the impacted area, who can be contacted and told everyone is ok.

IN THE AFTERMATH  
OF HURRICANE  
FLOYD, PETS  
ARE RESCUED IN  
NORTH CAROLINA.

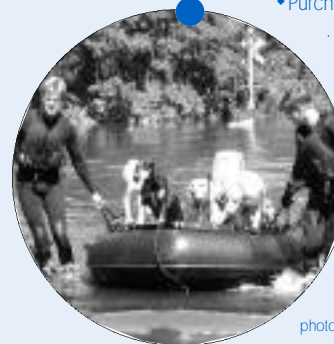


photo courtesy of FEMA

HURRICANE  
ANDREW LEFT  
HIS MARK.

## IT'S ALL IN THE NAME

Did you ever wonder why tropical storms and hurricanes are given names like Chantal and Felix? Weather watchers found that distinctive names are more easily and effectively communicated, reducing the confusion of using coordinates to label a storm. In 1953, the U.S. Weather Service began using women's names, abandoning an earlier plan to use names from the phonetic alphabet (Able, Baker, Charlie). Since 1979, men's names have been added to the list, which is now kept by an international committee of the World

Meteorological Organization. Six lists are used in rotation, so the names for 2002 will be used again in 2008, with one major exception. When a storm is particularly deadly or costly, the name is retired and a new name beginning with the same letter replaces it. On the 2002 list, Cristobal replaced Cesar, Fay replaced Fran, and Hanna replaced Hortense.

HERE ARE THE NAMES  
YOU CAN EXPECT TO  
SEE DURING THE 2002  
HURRICANE SEASON:

Arthur  
Bertha  
Christobal  
Dolly  
Edouard  
Fay  
Gustav  
Hanna  
Isidore  
Josephine  
Kyle  
Lili  
Marco  
Nana  
Omar  
Paloma  
Rene  
Sally  
Teddy  
Vicky  
Wilfred

## UNPREDICTABILITY AND PREPAREDNESS

Any tropical storm that reaches the Bahamas has the possibility to hit Massachusetts. The tracks of these fickle storms are extremely difficult to predict, however. In fact, the forecasted track of a hurricane 72 hours before expected landfall can be off by as much as 248 miles in any direction. At the 36 hour mark, this estimated error is only down to 127 miles, meaning that a storm expected to be a direct hit for Martha's Vineyard could ultimately make landfall as far west as the Connecticut River or as far east as George's Bank. Even 12 hours before landfall, the resolution is only within 47 miles.

This unpredictability exacerbates the biggest problem when a hurricane approaches: time to prepare. When few people lived along the coast, evacuation took little time. Now, even with the improvements in forecasting and the advanced warning coastal and riverside residents will receive, evacuations must be called for before the exact location of hurricane landfall is known with certainty. The Bourne and Sagamore bridges, for instance, close with winds of more than 75 mph, a condition that is likely to occur hours before the eye descends on the Cape. This means that summer visitors and permanent residents need at least 24 hours of lead time, when the forecast could be off by 88 miles. Boat owners face a similar guessing game. To have enough time to battle the crowds to

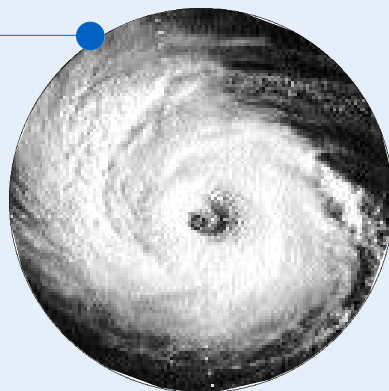
get your boat out of the water, over-congested ramps, and along packed roads—and then still have time to evacuate yourself and your family—you probably need at least 36 hours of advanced warning.

While prediction methods are continually improving, the vagaries of these complex weather patterns remain. Consequently, the best thing you can do if a major hurricane approaches is to listen to state, federal, and local emergency preparedness officials. They have the responsibility to make the tough calls about evacuations—and they need to make these calls with enough time to get everyone out safely.

Finally, when it comes to major storms, you can take steps to protect your family and your property. Over the years, we have learned a lot about how to build, rebuild, and otherwise prepare for the worst these storms can bring.

CZM has assembled additional information on what you need to know to be ready for a hurricane. See the *Hurricane Preparedness Kit* on page 8 for details and a Web address and telephone number to access this information. In addition, see *Coastal Construction Manual: A Great Tool for Protecting Homes from Storm Damage* on page 24 for more on construction strategies. By taking proper precautions, we can all be ready for whatever hurricane season 2002 brings.

ERIN AS SEEN  
FROM ABOVE.



FLOYD WAS HERE  
(AND LEFT A LOT OF  
WATER BEHIND IN  
FRANKLIN, VIRGINIA).



IGNACIO IN  
THE SKIES:  
A PLANE'S EYE  
VIEW OF  
HURRICANE  
IGNACIO,  
900 MILES  
SOUTHEAST  
OF HAWAII.

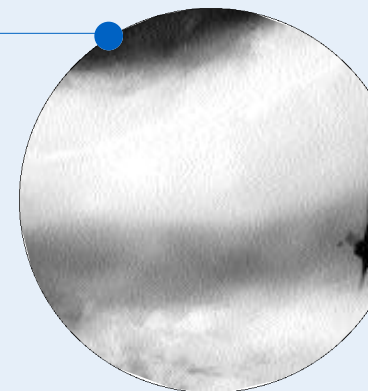


photo courtesy of Hurricane Hur

## 1 THROUGH 5: THE HURRICANE CATEGORIES

Wind speed dictates the potential damage that a hurricane can cause. The National Hurricane Center uses the Saffir/Simpson scale to classify hurricanes into five categories, based on wind speed.

**CATEGORY 1** - 74-95 mph sustained winds with 4-5 foot storm surge.

Minimal damage, including: flooding of low-lying coastal roads; minor pier damage; small, exposed vessels torn from moorings.

**CATEGORY 2** - 96-110 mph sustained winds with 6-8 foot storm surge.

Moderate damage, including: some wind damage to roofing material, doors, and windows; flooding of low-lying coastal escape routes 2-4 hours before eye passes; considerable damage to piers and mobile homes; marinas flooded; small vessels with unprotected anchorages torn from moorings.

**CATEGORY 3** - 111-130 mph sustained winds with 9-

12 foot storm surge. Extensive damage, including: destruction of smaller structures by coastal flooding and destruction of larger structures by battering waves and floating debris; mobile homes destroyed; low-lying roads flooded 3-5 hours before eye hits; terrain less than 5 feet above sea level flooded for up to 8 miles inland.



**CATEGORY 4** - 131-155 mph winds with 13-18 foot storm surge. Extreme damage, including: some complete roof failure of small residences; flooding of flat terrain up to 10 feet above sea level, as far as 6 miles inland; major damage from flooding and wave battering to lower floors of structures near shore; major beach erosion; low-lying roads flooded 3-5 hours before eye hits.

**CATEGORY 5** - Greater than 155 mph winds and storm surge over 18 feet. Catastrophic damage, including: complete roof failure of many residences and industrial buildings; some complete building failure with small utility buildings blown over or away; damage to lower floors of structures less than 15 feet above sea level, within 500 yards of shore; massive evacuation of residential areas within 5-10 miles of shoreline may be required.

AN EXAMPLE OF  
ANDREW'S DAMAGE...  
THE PROPERTY OWNER  
PUTS INFORMATION  
ON THE REMAINS OF  
THE PROPERTY TO MAKE  
IT EASIER FOR AGENTS  
TO ASSESS THEIR  
COLLECTION  
ALLOWABLES.

HELL HATH NO FURY  
LIKE THE HURRICANE  
OF '38... MAIN STREET  
IN WOODS HOLE.

